Limerick City & County Council in partnership with Limerick Twenty Thirty DAC

Cleeves Riverside Quarter

Engineering Services Report

Reference: CRQMP-ARUP-ZZ-ZZ-RP-CE-0001

C01 | 03 October 2025

Job number 277975-00

Ove Arup & Partners Ireland Limited
50 Ringsend Road
Dublin 4
D04 T6X0
Ireland
arup.com

Document Verification

Project title	Cleeves Riverside Quarter
Document title	Engineering Services Report
Job number	277975-00
Document ref	CRQMP-ARUP-ZZ-ZZ-RP-CE-0001
File reference	4-04-01

Revision	**Date**	**File name**	CRQMP-ARUP-ZZ-ZZ-RP-CE-0001		
C01	03 October 2025	**Description**	Issue for Planning (Status A2)		
			Prepared by	**Checked by**	**Approved by**
		Name	Ana Sofijanic	Gregg Sim	Noel Sheridan
		Signature			

Issue Document Verification with Document ✓

Contents

Tables

Figures

Appendices

1. Introduction

This Engineering Services Report has been prepared on behalf of Limerick City & County Council in partnership with Limerick Twenty Thirty DAC (LTT) as part of a planning application for the proposed Cleeves Riverside Quarter Development.

Limerick City and County Council, in partnership with Limerick Twenty Thirty DAC, intends to seek the approval of An Coimisiún Pleanála in accordance with Section 175 and 177AE of the Planning and Development Act 2000, as amended, for a mixed-use development that seeks the regeneration and adaptive reuse of a strategic brownfield site, as part of the Limerick City and County Council 'World Class Waterfront revitalisation and transformation project'.

The purpose of this report is to outline the civil engineering design (drainage and watermains) proposal for the Cleeves Riverside Quarter (CRQ).

2. The Proposed Development

The proposed development comprises Phase II, of an overall Masterplan with four phases of development proposed. Phase II is subsequent to ongoing stabilisation and repair of the Flaxmill protected structure (Phase I). Phase III is intended to comprise an educational campus, inclusive of the adaptive reuse of the Flaxmill Building as part of that development and will be subject to a future separate application. Phase IV comprising the Shipyard site will be the final phase of development.

The proposed development provides for the (A) Demolition of a number of structures to facilitate development and (B) Construction and phased delivery of (i) buildings within the site ranging in height from 3 – 7 stories (with screened plant at roof level) including (a) 234 no. residential units; (b) 270 no. student bedspaces (PBSA) with ancillary resident services at ground floor level; (c) 256sqm of commercial floorspace; and (d) a creche; (ii) extensive public realm works, (iii) riverside canopy and heritage interpretative panels, (iv) 3 no. dedicated bat houses; (v) Mobility Hub with canopy; and (vi) all ancillary site development works including (a) water services, foul and surface water drainage and associated connections across the site and serving each development zone; (b) attenuation measures; (c) raising the level of North Circular Road; (d) car and bicycle parking; (e) public lighting; (f) telecommunication antennae and (g) all landscaping works. Consent is also sought for use of the PBSA accommodation, outside of student term time, for short-term letting purposes.

The engineering services report examines the phase II development with consideration to future developments in the wider Masterplan.

2.1 Site Location

The site, known locally as 'Cleeves Riverside Quarter' comprises the former industrial mill complex ('Cleeves') situated on the northern side of the River Shannon, Limerick City and occupies the area between; Stonetown Terrace Road to the northeast; O'Callaghan Strand to the southeast; Condell Road (R527) to the southwest; and, Salesian Primary School and the 'Fernhill' residential estate to the northwest and west respectively - all situated in the townland of Farranshone More in Limerick City. The site is dissected by North Circular Road where it extends between Shelborne Road Lower and O'Callaghan Strand.

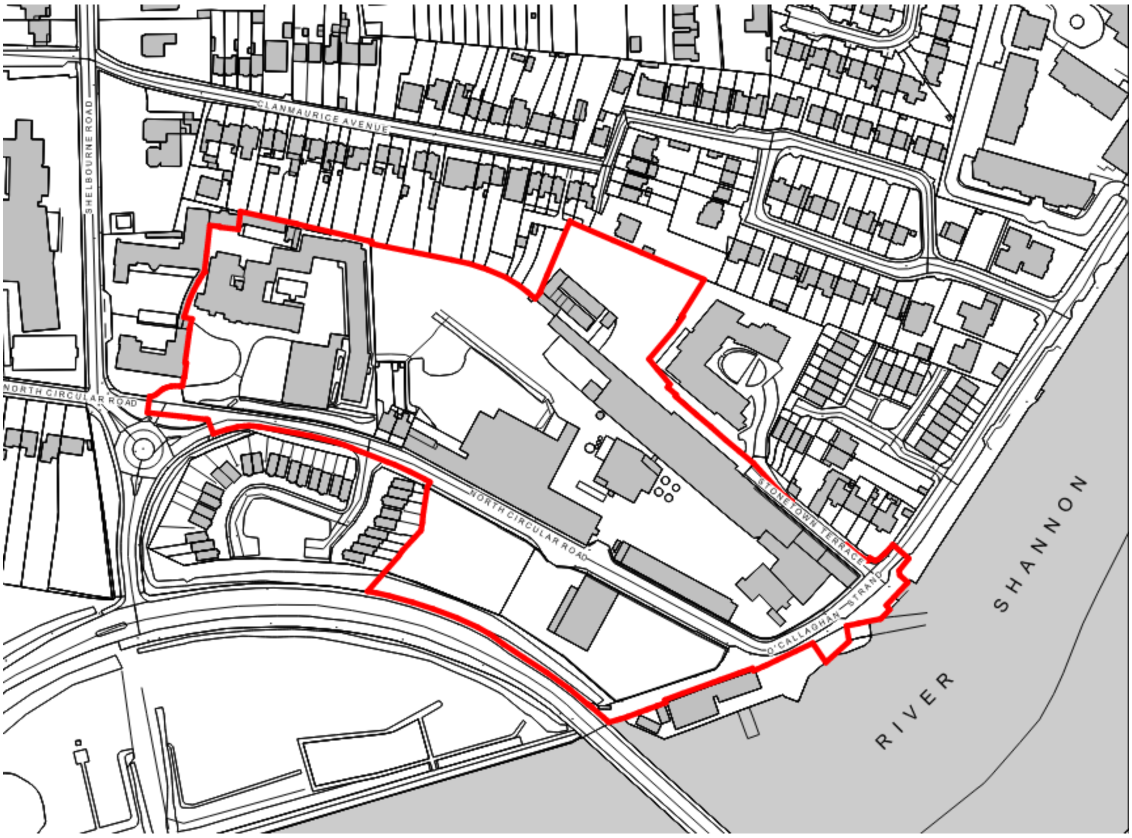

Figure 1: Application Boundary

3. Reference Documents

The basis of the SuDS and drainage strategies outlined in this report are founded on the principles detailed in the below list of documents:

- Part H of the Building Regulations
- BS EN 752 Drain and Sewer Systems outside Buildings
- Limerick Development Plan 2022 to 2028
- CIRIA report C753 The SuDS Manual
- The Greater Dublin Regional Code of Practice for Drainage Works and Irish Water requirements.

4. Background Surveys

4.1 Topographical

A topographical survey of the existing site was carried out by Geodata Chartered Land Surveyors. Refer to Appendix C1 or the site topographical survey. The survey includes contours, spot levels on the site (all to Malin Head datum), the site boundary, road and kerb lines bounding the site as well as existing drainage, chambers and additional services within the site.

4.2 Utility

A utility survey of the existing site has been carried out by Precision Utility Mapping. Refer to Appendix C2 for the existing utility survey in the vicinity of the site.

4.3 CCTV Survey

A detailed CCTV survey of the existing process, foul and surface water drainage systems within the former Cleeves, Salesians and Shipyard sites was undertaken. McBreen carried out the work in 2024 with the CCTV survey confirming the extent and condition of onsite networks and connections to the Uisce Éireann network along the North Circular Road (NCR).

5. Drawings

Refer to Appendix A for the engineering drawings that accompany this report.

6. Existing Services

There is an existing 150mm surface water pipe from the Salesians site that is discharging directly to the combined sewer on NCR via a 300mm internal combined drainage network. There is an existing 225mm Surface Water Sewer serving the apartments at the top of Stonetown Terrace.

There appears to be a 400mm surface water outfall (discharge) via an existing pipe at the Shannon River's north bank from the Flaxmill site. The CCTV survey shows that there are a series of pipes that link the Shannon River to the reservoir from this feature. There was confirmation in early March 2021 of the existence of a flap-gate access point to the Reservoir in the area below the infiltration gallery which has an invert level of 0.33m. The last manhole before the Shannon River has a higher invert level (0.99m), which suggests that the link was designed to drain water from the Shannon River to the reservoir to be used for the industrial process on site. The flap-gate at the reservoir no longer works and thus allows water to enter in either side of the pipe depending on the resultant water level in the Shannon River. The Verde Hydrographic Report from 2021 shows that the tide in the reservoir fluctuates from a minimum low tide of +0.99m ODM to a maximum high tide at +2.00m ODM.

There is a 200mm diameter watermain crossing the Shannon bridge and connecting to a 150mm diameter watermain surrounding the site on the lower NCR, O'Callaghan Strand and on Stonetown Terrace.

There is a large diameter combined sewer located on the lower North Circular Road (NCR) which is indicated as being connected to a 1.8m diameter combined sewer crossing the river just northeast of St Michael's Rowing Club. It is understood that these sewers were installed as part of the Limerick Main Drainage Scheme (LMDS) in the early 2000's. The existing combined sewer in the lower North Circular Road (NCR) between the two sites (Flaxmill & Shipyard) is 1050mm in diameter and has a shallow hydraulic gradient of circa 1/400.

7. Proposed Services

7.1 Proposed Surface Water

7.1.1 Design Criteria

It is proposed to discharge the surface water from the development to the Shannon River via the existing 400 mm diameter discharge pipe. The overall objective is to drain each site as an independent network to enable phasing of the works.

Surface water infrastructure and attenuation facilities will be designed to service a volume equivalent to a 1 in 100-year event plus 30% for climate change and 10% urban creep in agreement with Limerick County Council. Exceedance events beyond the 1 in 100-year will be channelled towards sacrificial areas away from buildings. Building finished floor levels will be raised above adjacent ground levels to an extent commensurate with the flood risk considerations for the individual areas, as a further protection measure.

The aim is to restrict surface water peak discharges from the Cleeves development site to 2 litres/second/hectare, in line with the GDSDS and Limerick City & County Council Water Services requirements, prior to discharge to the Shannon River. Moreover, the critical requirement will be that the final rate of flow discharge that leaves the site does not exceed the current levels.

The primary objective is to use the reservoir as an attenuation facility, managing surface water runoff from the adjacent Salesians, PBSA, and Stonetown Terrace sites. Controlled discharge from the reservoir will be facilitated via a 225 mm diameter outlet pipe, which will traverse through the Flaxmill Plaza site and connect to the final manhole before discharging to the River Shannon.

The remaining development areas—including Flaxmill Plaza, O'Callaghan Strand, Shipyard, and the adjacent roads (NCR, OCS, and Stonetown Road)—will drain independently to the existing discharge pipe network.

Surface water runoff from all internal drainage networks will be treated prior to discharge using a combination of Sustainable Drainage Systems (SuDS) and petrol interceptors, ensuring compliance with water quality and environmental standards.

The overarching strategy for surface water management is to prioritise the implementation of Sustainable Urban Drainage Systems (SuDS) across all development sites. This implementation of SUDS will help to achieve the key objectives of:

- Managing runoff close to source
- Limiting peak discharges to pre-development levels
- Maintaining or improving runoff quality
- Integrating stormwater management and control into the landscape design for the benefits of amenity and recreation
- Mimicking the way existing groundwater, drainage channels and wetlands are supplied with water
- Installing petrol interceptors in all areas with potential exposure to hydrocarbons e.g. car parks
- Minimising the use of buried attenuation tanks (by exception only)
- Use of natural materials for check dams in swales, consider use of recovered rock from site
- Designing detention basins to have various states of water retention to enhance biodiversity and add interest to the landscape
- Planting to comprise of species with low water demand
- Infrastructure plot boundaries to be defined to provide sufficient footprint for implementation of proposed SuDS strategy.

The range of SuDS measures on individual plots will vary from site to site. Ideally systems should treat and control the run-off as close as possible to the source. A Management Train that incorporates a series of features will be incorporated to ensure that the series of features treats and attenuates the stormwater run-off where possible.

Reservoir as attenuation facility

Excess runoff from adjacent sites and SuDS features is routed to the reservoir for attenuation. Surface water calculations prove that there is sufficient capacity in the reservoir to attenuate excess runoff for a 1:100 year storm (plus 30% climate change and 10% urban creep) from the surrounding sites. The total required attenuation volume is 1597.6m^3.

A 225 mm diameter outlet pipe is proposed to be laid horizontally from the reservoir to the final discharge manhole, with an invert level of +1.00 m ODM. During attenuation, the water level within the reservoir is expected to rise to +1.90 m ODM, maintaining a freeboard of 2.90 m relative to the proposed ground level at the PBSA (+4.80 m ODM), ensuring adequate flood protection.

A reservoir clean-up strategy be implemented during the construction phase. This should include:

- Controlled draining of the reservoir
- Removal of accumulated sediment
- Survey and inspection of the reservoir bed.

Final manhole within planning boundary

The existing final manhole (ExMHC112) located at the southern boundary of the site, which includes a penstock, is in poor structural condition. It is proposed to construct a new offline manhole (SMH100) adjacent to the existing structure (to keep the existing system operational during construction). The new manhole will be fitted with a TideFlex non-return valve to prevent backflow and protect the site from flooding from the outfall pipe.

Once the new manhole is operational, the existing manhole will be decommissioned and demolished and the discharge pipe from the reservoir will be extended to connect to the new manhole.

7.1.2 Design Rainfall

The Limerick rainfall depth for various return periods and storm duration are provided by Met Eireann as indicated in the following table:

Table 1: Limerick rainfall data

Met Eireann
Return Period Rainfall Depths for sliding Durations
Irish Grid: Easting: 156985, Northing: 157075,

	Interval		Years										
DURATION	6months,	1year,	2,	3,	4,	5,	10,	20,	30,	50,	75,	100,	120,
5 mins	2.8,	3.9,	4.6,	5.5,	6.2,	6.7,	8.4,	10.3,	11.6,	13.4,	15.0,	16.2,	17.0,
10 mins	3.9,	5.5,	6.4,	7.7,	8.6,	9.3,	11.7,	14.3,	16.1,	18.6,	20.8,	22.6,	23.8,
15 mins	4.5,	6.5,	7.5,	9.1,	10.2,	11.0,	13.7,	16.9,	19.0,	21.9,	24.5,	26.6,	27.9,
30 mins	5.9,	8.2,	9.4,	11.3,	12.5,	13.5,	16.7,	20.2,	22.6,	25.9,	28.8,	31.0,	32.5,
1 hours	7.6,	10.4,	11.9,	14.0,	15.5,	16.6,	20.2,	24.3,	26.9,	30.6,	33.8,	36.3,	37.9,
2 hours	9.8,	13.2,	14.9,	17.5,	19.1,	20.4,	24.6,	29.1,	32.0,	36.1,	39.6,	42.4,	44.2,
3 hours	11.4,	15.1,	17.1,	19.8,	21.7,	23.1,	27.5,	32.4,	35.5,	39.8,	43.5,	46.4,	48.3,
4 hours	12.7,	16.7,	18.8,	21.7,	23.6,	25.1,	29.8,	34.9,	38.2,	42.7,	46.5,	49.5,	51.4,
6 hours	14.8,	19.2,	21.4,	24.7,	26.8,	28.4,	33.4,	38.8,	42.3,	47.0,	51.1,	54.2,	56.2,
9 hours	17.2,	22.1,	24.5,	28.0,	30.3,	32.0,	37.4,	43.2,	46.9,	51.8,	56.1,	59.4,	61.5,
12 hours	19.2,	24.4,	26.9,	30.7,	33.0,	34.9,	40.5,	46.6,	50.4,	55.5,	60.0,	63.3,	65.5,
18 hours	22.3,	28.0,	30.8,	34.8,	37.4,	39.3,	45.4,	51.8,	55.8,	61.2,	65.9,	69.3,	71.6,
24 hours	24.8,	30.9,	33.9,	38.1,	40.8,	42.9,	49.2,	55.9,	60.0,	65.6,	70.4,	74.0,	76.3,
2 days	31.8,	38.8,	42.2,	47.0,	50.1,	52.3,	59.4,	66.7,	71.2,	77.2,	82.3,	86.1,	88.6,
3 days	37.9,	45.7,	49.5,	54.8,	58.2,	60.7,	68.3,	76.2,	81.1,	87.5,	93.0,	97.0,	99.7,
4 days	43.5,	52.1,	56.2,	61.9,	65.6,	68.3,	76.5,	84.9,	90.1,	97.0,	102.8,	107.1,	109.9,
6 days	53.8,	63.7,	68.5,	75.0,	79.1,	82.2,	91.5,	100.9,	106.7,	114.3,	120.7,	125.4,	128.5,
8 days	63.5,	74.6,	79.9,	87.1,	91.7,	95.0,	105.2,	115.6,	121.9,	130.2,	137.1,	142.2,	145.5,
10 days	72.7,	84.9,	90.7,	98.6,	103.6,	107.2,	118.3,	129.4,	136.2,	145.1,	152.5,	158.0,	161.5,
12 days	81.6,	94.9,	101.1,	109.7,	115.0,	118.9,	130.7,	142.7,	149.9,	159.4,	167.2,	173.0,	176.8,
16 days	99.0,	114.1,	121.2,	130.9,	136.9,	141.3,	154.6,	167.9,	176.0,	186.5,	195.2,	201.6,	205.7,
20 days	115.8,	132.7,	140.6,	151.3,	157.9,	162.8,	177.4,	192.0,	200.8,	212.3,	221.8,	228.7,	233.2,
25 days	136.4,	155.4,	164.2,	176.1,	183.5,	188.9,	205.0,	221.1,	230.8,	243.4,	253.7,	261.3,	266.2,

NOTES:
These values are derived from a Depth Duration Frequency (DDF) Model update 2023
For details refer to:
'Mateus C., and Coonan, B. 2023. Estimation of point rainfall frequencies in Ireland. Technical Note No. 68. Met Eireann',
Available for download at:
http://hdl.handle.net/2262/102417

To perform the hydraulic calculations for the Cleeves Riverside Quarter development, a critical storm of 1:100 year, 6-hour storm, with rainfall depth of 54.2mm was used. Allowing for 30% climate change and 10% urban creep we then used a rainfall depth of 77.53mm for sizing of surface water infrastructure and the SuDS components. Refer to Appendix B.1 for the critical storm calculation.

7.1.3 Run-off Coefficient

Selection of a run-off coefficient can be somewhat subjective and there is a vast amount of literature advising on appropriate factors for various ground types, slopes etc. The table below provides a comprehensive selection of potential run-off coefficients for different land uses, soil types and slopes:

Table 2: Runoff coefficient

Land use	Slope (%)	Sand	Loamy sand	Sandy loam	Loam	Silt loam	Silt	Sandy clay loam	Clay loam	Silty clay loam	Sandy clay	Silty Clay	Clay
Forest	<0,5	0.03	0.07	0.10	0.13	0.17	0.20	0.23	0.27	0.30	0.33	0.37	0.40
	0,5–5	0.07	0.11	0.14	0.17	0.21	0.24	0.27	0.31	0.34	0.37	0.41	0.44
	5–10	0.13	0.17	0.20	0.23	0.27	0.30	0.33	0.37	0.40	0.43	0.47	0.50
	>10	0.25	0.29	0.32	0.35	0.39	0.42	0.45	0.49	0.52	0.55	0.59	0.62
Grass	<0,5	0.13	0.17	0.20	0.23	0.27	0.30	0.33	0.37	0.40	0.43	0.47	0.50
	0,5–5	0.17	0.21	0.24	0.27	0.31	0.34	0.37	0.41	0.44	0.47	0.51	0.54
	5–10	0.23	0.27	0.30	0.33	0.37	0.40	0.43	0.47	0.50	0.53	0.57	0.60
	>10	0.35	0.39	0.42	0.45	0.49	0.52	0.55	0.59	0.62	0.65	0.69	0.72
Crop	<0,5	0.23	0.27	0.30	0.33	0.37	0.40	0.43	0.47	0.50	0.53	0.57	0.60
	0,5–5	0.27	0.31	0.34	0.37	0.41	0.44	0.47	0.51	0.54	0.57	0.61	0.64
	5–10	0.33	0.37	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70
	>10	0.45	0.49	0.52	0.55	0.59	0.62	0.65	0.69	0.72	0.75	0.79	0.82
Bare	<0,5	0.33	0.37	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70
soil	0,5–5	0.37	0.41	0.44	0.47	0.51	0.54	0.57	0.61	0.64	0.67	0.71	0.74
	5–10	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80
	>10	0.55	0.59	0.62	0.65	0.69	0.72	0.75	0.79	0.82	0.85	0.89	0.92
IMP		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

For the purposes of the hydraulic calculations in this report we have adopted the following run-off factors:

Table 3: Adopted Runoff coefficients

Land Use	Run-off coefficient
Green Space	0.2 (From table above)
Gravel	0.8
Hard Standing	1.0
Safety Surfacing	0.7
Reservoir Water Body	1.0
Porous Paving	0.6 (As per BS 8515:2009+A1:2013)
Rain Garden	0.7 (on the assumption circa 30% rainfall gets intercepted)
Raised Planters	0.7 (on the assumption circa 30% rainfall gets intercepted)
Tree Pits	0.7 (on the assumption circa 30% rainfall gets intercepted)
Green Roof (Extensive)	0.6 (As per BS 8515:2009+A1:2013)
Swale	1.0 (throttled and attenuated in situ)

7.1.4 Green Infrastructure

The overall strategy for surface water management is to maximise the SuDS features on all the sites within the Cleeves Riverside Quarter development (Salesians, PBSA, Stonetown Terrace, Flaxmill, O'Callaghan Strand and Shipyard).

Principles of Green infrastructure

Green Infrastructure (GI) is a strategically planned and delivered network of natural and man-made green (land) and blue (water) spaces that sustain natural processes (CIRIA, 2014). GI delivers a wide variety of benefits for biodiversity, amenity, health and wellbeing and climate change adaptation. GI can be subdivided into assets and functions that may be a park, woodland, green roof or street tree (to name a few) and can range in terms of both size and scale. GI functions relate to the roles that the assets can play if planned and managed in a way that is sensitive to, and includes provision for, natural features and ecosystems services.

The Primary Objective of GI in the context of drainage is to improve the status quo (which has prioritised volumetric control of run-off over at-source volumetric control and water quality improvement) by bringing a new approach to creating sustainable development through Water Sensitive Urban Design.

Water Sensitive Urban Design is the process of integrating water cycle management with the built environment. It is about using the transition of water through communities to add value, to enhance the wellbeing of the people and their environment, both natural and man-made, in a way which is aesthetically pleasing and adds to our overall appreciation and enjoyment of the setting. For new developments, water and its management needs to be central to the planning and urban design ethos.

Arup has identified the elements in the adjacent graphic as core to successful and lasting Water Sensitive Urban Design strategies. In a world of growing populations and changing climates, water management is of key importance for the health and wellbeing of our planet. Arup thinks and plans at catchment scale and fully integrates with the planning and management of urban systems to deliver Water Sensitive Urban Design.

We propose a concept for achieving water supply resilience through blue and green thinking.

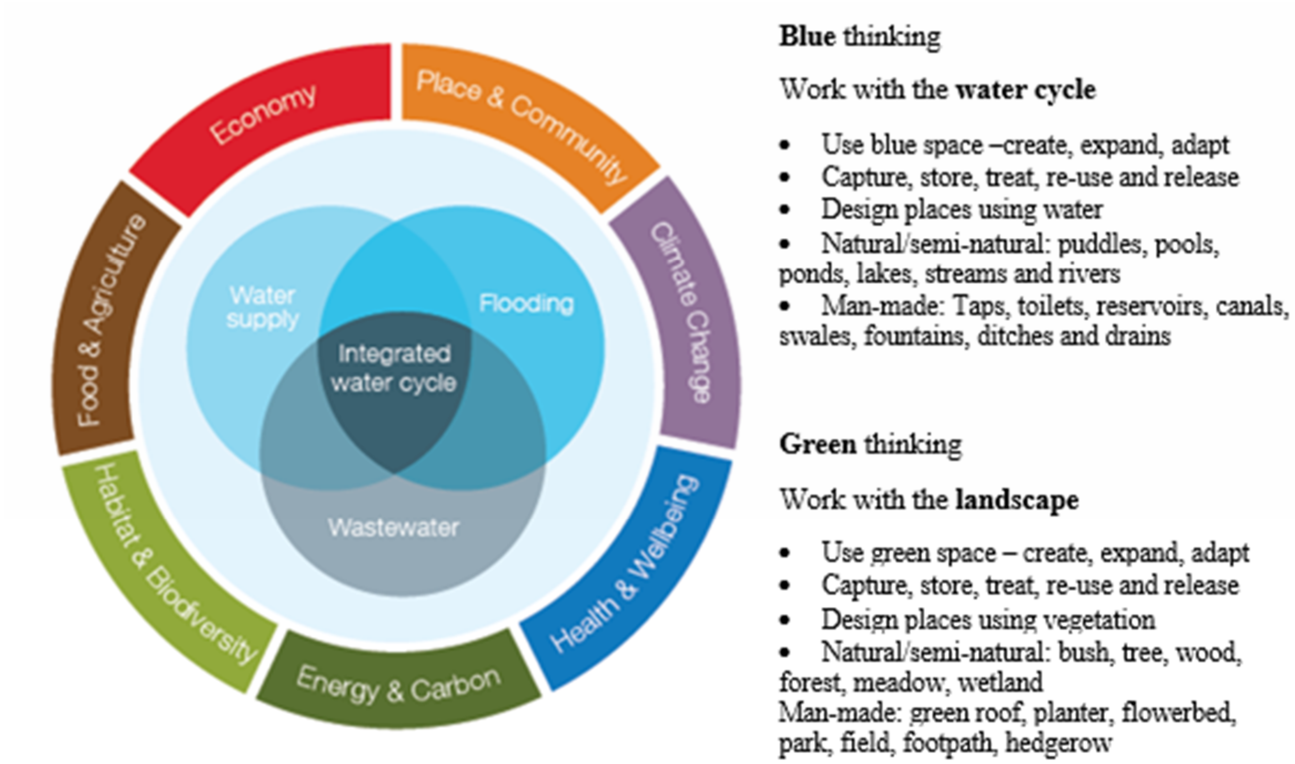

Figure 2: Sustainable Drainage Systems (SuDS) © CIRIA

7.1.5 SuDS

As part of the Cleeves development Arup propose to implement SuDS to the maximum extent possible across the full extent of the site, with the intention of filtering and storing rainfall at source. This will be achieved through a range of techniques and associated flow controls.

Sustainable drainage systems are designed to maximise the opportunities and benefits that can be secured from surface water management. SuDS can take many forms, both above and below ground, and they facilitate four main categories of benefits (water quantity, water quality, amenity and biodiversity).

SuDS deliver high quality drainage while supporting urban areas to cope better with severe rainfall both now and in the future. SuDS also help counteract some of the impacts in the water cycle caused by increased urbanisation, such as reduced infiltration, which in turn can result in diminished groundwater supplies.

The various available solutions for SuDS require a coordinated design between engineering, sustainability consultancy and landscape design.

A Management Train comprising of a series of features will be implemented where feasible to ensure that the series of features treat and attenuate the stormwater run-off to an acceptable quality at greenfield rates of flow. Ideally systems should treat and control the run-off as close as possible to the source.

Several SuDS components in a Management Train facilitates the capture, conveyance and storage of surface water runoff while delivering interception and pollutant risk management. An impermeable lining will be installed beneath the porous paving and rain gardens to prevent infiltration into the made ground, thereby eliminating the risk of pollutant transfer.

The suitability of different SuDS techniques in a Management Train is indicated in the following table:

Table 4: SuDS components within a management train

Indicative suitability of SuDS components within the Management Train				
SuDS component	**Interception[1]**	**Close to source/ primary treatment**	**Secondary treatment**	**Tertiary treatment**
Rainwater harvesting	Y			
Filter strip	Y	Y		
Swale	Y	Y	Y	
Filter drain	Y		Y	
Pervious pavements	Y	Y		
Bioretention	Y	Y	Y	
Green roof	Y	Y		
Detention basin	Y	Y	Y	
Pond	[3]	Y[2]	Y	Y
Wetland	[3]	Y[2]	Y	Y
Infiltration system (soakaways/ trenches/ blankets/basins)	Y	Y	Y	Y
Attenuation storage tanks	Y[4]			
Proprietary treatment systems		Y[5]	Y[5]	Y[5]

7.1.6 Proposed SuDS Techniques

Arup proposes the implementation of a Sustainable Urban Drainage Systems (SuDS) strategy across the Cleeves Riverside Quarter development, aligned with the overarching surface water management philosophy. For the purpose of describing the surface water design strategy, the development has been defined as two distinct zones:

- Zone 1: This zone encompasses the primary development sites, where dedicated attenuation facilities and SuDS features have been proposed. These include: Salesians, PBSA, Stonetown Terrace, Reservoir, Flaxmill Plaza, O'Callaghan Strand, and Shipyard. Catchments have been delineated around each site to optimise runoff management and integrate SuDS measures such as rain gardens, permeable paving, and green roofs.
- Zone 2: This zone includes surrounding road infrastructure with limited space for SuDS implementation and no conventional attenuation facilities. These areas include: North Circular Road, O'Callaghan Strand Road, and Stonetown Terrace Road. Due to spatial constraints, conventional drainage systems will be used, supplemented by targeted SuDS interventions where feasible.

Refer to Appendix B.2 for the extents of Zones 1 and 2.

The proposed SuDS scheme includes the following features for the two zones.

Table 5: Zone 1 SuDS features

Site	Rain Gardens	Tree Pits	Raised Planters	Porous Paving	Swales	Green Roof
Salesians	☑			☑		☑
PBSA			☑	☑		☑
Stonetown Terrace	☑			☑		☑
The Flaxmill Plaza	☑	☑				
O'Callaghan Strand				☑		
Shipyard				☑	☑	

Table 6: Zone 2 SuDS features

Site	Rain Gardens	Tree Pits	Porous Paving
North Circular Road	☑		☑
O'Callaghan Strand Road		☑	
Stonetown Terrace Road			☑

Green Roofs

These are roofs that are adapted or designed to support plants. They are areas of living vegetation, installed on the top of buildings for a range of reasons including visual benefit, ecological value, enhanced building performance and the reduction of surface water run-off. Green roofs offer many benefits including:

- Supporting biodiversity
- Providing cooler buildings in summer
- Cleaning run-off
- Reducing run-off for day-to-day rain.

Green roofs can be installed on a variety of roof types, sizes and slopes. They principally come in two forms – extensive (low substrate depth) and intensive (deeper substrates). Both types are unlikely to increase the load on a roof by more than 20%. Arup has agreed with the architects that an extensive green roof type would be used for the Cleeves development project due to lower maintenance cost.

The principal components of a green roof structure are:

- Waterproof membrane
- Root barrier
- Drainage layer
- Geotextile filter layer
- Soil or growing medium
- Vegetation.

Green roofs absorb most of the rainfall during frequent events but have a similar hydraulic performance to standard roofs once saturated. They can be assumed to meet interception requirements in the summer months based on their minimum retention of 5 to 10mm of rainfall. They can reduce the peak flow and volume of run-off in warmer periods when the soil moisture deficit is high. They are unlikely to perform as well during the winter months when they are likely to be saturated for much of the time. Green roofs are proposed for the Salesians, PBSA and Stonetown Terrace sites, with a coverage of 25% of the total roof area for PBSA and Stonetown Terrace, and 15% coverage of the total roof area for the Salesians site.

Refer to drawing CRQMP-ARUP-XX-00-DR-CE-4407 for proposed green roof details.

Raised planted areas/Rain gardens/Tree pits (bioretention systems)

Bioretention systems are shallow landscaped raised/depressed areas that can reduce runoff rates and volumes and treat pollution through the use of engineered soils and vegetation. They are particularly effective in delivering interception and can also provide attractive landscape features, habitat and biodiversity and cooling of the local microclimate due to evapotranspiration.

Runoff collected by the system ponds temporarily on the surface and then filters through the vegetation and underlying soils. Specified engineered soil mixes can be used as filter media to enhance bioretention treatment performance. Part of the runoff volume is removed through evaporation and plant transpiration, with excess filtered runoff being collected in a perforated underdrain system.

They are generally used for managing runoff from frequent rainfall events, however attenuation storage on the surface or within the drainage layer can be used to help manage runoff rates. Check dams or weirs can also be used to slow the flow of water moving across the surface of the system.

We propose connecting the rainwater downpipes from the hard standing roof areas to raingardens at ground level, which will be sized to collect and store up to the 1 in 100-year rainfall event.

The principal components of a bioretention system are:

- Vegetation (uptake of pollutants and nutrient removal)
- Filter medium (sand based with organic matter, controls rate at which water filters through the system)
- Transition layer (for filtering of fines, could also be a geotextile)
- Drainage layer (collects water from filter medium and directs to perforated pipes)
- Impermeable lining to avoid infiltration to made ground
- Perforated pipes (collect water from the system and convey it downstream)
- Overflow (diverts exceedance flows to downstream system)

We propose a range of bioretention planting to manage surface water run-off in the following areas:

- Raised planted areas on level 1 of the PBSA development
- Rain gardens at ground level at Salesians, PBSA, Stonetown Terrace, and Flaxmill Plaza
- Tree pits at ground level at Flaxmill Plaza

Refer to Appendix B.3 and B.4 for the location of the proposed bioretention areas and Drawing 1AR-ARUP-ZZ-XX-DR-C-4407 in Appendix A for proposed bioretention planted area details.

Porous/Permeable Paving

These are hard surfaces that can also support vehicles, which also allow rainfall to soak into the ground or into underground storage to slow the release of runoff. Porous surfaces, together with their associated substructures, are an efficient means of managing surface water runoff close to its source – intercepting runoff, reducing the volume and frequency of runoff, and providing a treatment medium.

Building Regulations Part H indicates that Soakaways should not be constructed within 5 m of a building, this 'rule' is usually applied where infiltration within the 5m offset from the foundation is not permitted. We propose a no infiltration philosophy for the Cleeves Riverside Quarter project as the porous pavement is within 5m of the proposed building.

Porous pavements are not suitable in areas at high risk of silt loads. They generally require flow controls at the outlets to ensure effective use of the storage in the subbase. The design thickness will be the greater of:

- Required thickness for hydraulic storage
- Required thickness structurally

If the site is sloping (as is the case for the Salesians and Stonetown Terrace sites), then check dams will be required at intervals to maximise the storage in the substructure.

We propose porous paving in the following locations:

- All car parking bays at Shipyard.

- The area bounded by the southeastern face of the O'Callaghan Strand Building and O'Callaghan Strand Road.
- Car parking bays to the east of Stonetown Terrace, along with pedestrian walkways within the Stonetown Terrace site.
- Pedestrian walkways within the southern and western areas of the PBSA site.

The porous paving will be sized to collect and store up to the 1 in 100-year rainfall event where feasible.

The extent of the proposed porous paving are shown in Appendix B.3 & B.4 for Zone 1 & 2 respectively.

Swales

Swales are shallow, flat bottomed, vegetated open channels designed to convey, treat and often attenuate surface water runoff. They can enhance the natural landscape and provide aesthetic and biodiversity benefits. They are designed to slow the water thereby facilitating sedimentation, filtration through the root zone and soil matrix, evapotranspiration and infiltration into the underlying soil.

On sites with steeper gradients, swales can have berms or check dams across the flow path to temporarily pond runoff, reduce velocities and increase pollutant retention and infiltration.

\\Features of the proposed swales include:

- Bottom width 0.5 – 2.0m
- Longitudinal gradient 0.5 – 6%
- Maximum side slope 3%
- Maximum depth up to 600mm

We propose a network of swales on the Shipyard site to take excess runoff from the surrounding road and ground level hard areas and gravel zone. The swales discharge to a collector drain which connects to the internal network and runs to the which also collects runoff from the porous paving. The swales will be fitted with orifice plates to restrict the discharge rate, to encourage infiltration and to attenuate runoff.

Refer to Appendix B.3 for locations of the swales at the Shipyard site and drawing CRQMP-ARUP-ZZ-XX-DR-CE-4406 for a proposed swale detail.

The management train for the proposed SuDS scheme is:

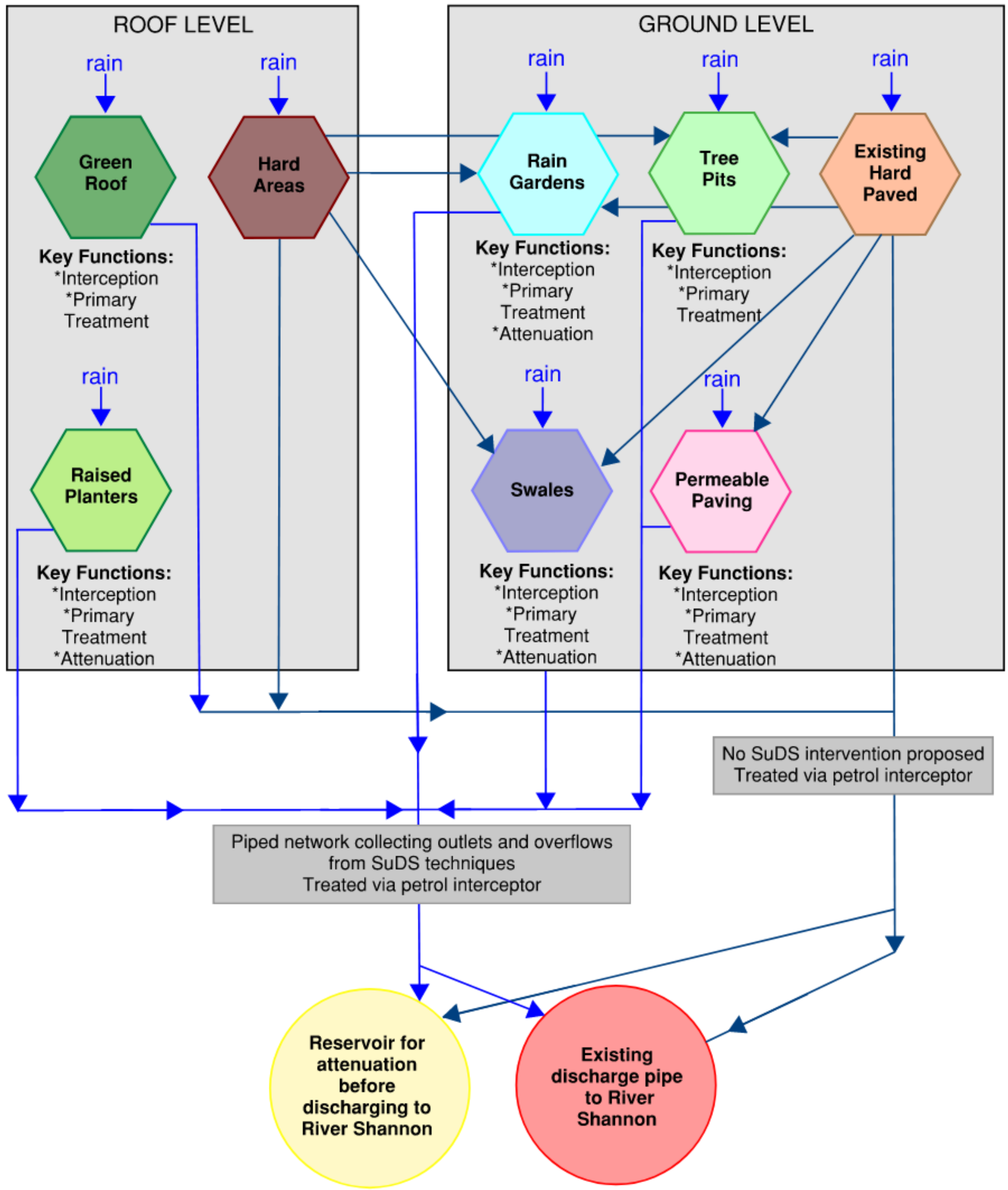

Figure 3: Site Wide SuDS schematic and management train

7.1.7 Catchment Delineation per Zone

For hydraulic calculations, each site within the Cleeves development has been divided into catchments based on SuDS technique/surface finish/topography. Refer to Appendix B.3 and B.4 for the SuDS catchment delineations for Zone 1 and 2 respectively.

Zone 1 (Site catchments):

The catchments for Zone 1 are summarised in the following table:

Table 7: Zone 1 catchments

Site	Catchment Name	Details	Total Area (m^2)
Salesians	GS43-44; GS46-54; GS55-76; GS77-83; GS90-107	Green Space	1633
	RG26-29; RG30-37	Raingarden	285
	G3-9	Gravel	679
	H8-H11; CHS7-9	Hard Standing	6735
	GR5-6	Green Roof	430
	SS4	Safety Surfacing	84
	PPT5-PPT6	Porous Paving	167
PBSA	H12; CHS6; CHS13; H4.1; H3.1; CHS1	Hard Standing	4674
	RG22-25	Raingarden	231
	RP1-3	Raised Planters	61
	GR3-4.1	Green Roof	385
	GS33-42; GS13-14; GA5-8; TGS13-20	Green Space	860
	SS1; SS2	Safety Surfacing	192
	PP5	Porous Paving	493
Stonetown Terrace	GS18-27; GS28.1; GS28.2; GS31-32; GS70; GA1-4	Green Space	986
	RG18-21	Raingarden	34
	G2	Gravel	64
	GR1-2	Green Roof	326
	PP4; PP6-7	Porous Paving	400
	CHS4; H6-7; RHT2	Concrete Hard Standing	1981
Reservoir	GS90-94; TGS21	Green Space	488
	RES1	Reservoir Water Body	2763
	H13.2; CHS10-12	Hard Standing	2104
The Flaxmill Plaza	H3.2; H4.2; H13.1; CHS2-3	Hard Standing	8277
	GS8-10; GS13-14; TGS1-19	Green Space	529
	TP1-6	Tree Pit	268
	RG1-2	Raingarden	121
O'Callaghan Strand	GS15-17; GS108	Green Space	26

Site	Catchment Name	Details	Total Area (m²)
	PP2	Porous Paving	236
	CHS3; H5	Hard Standing	1613
Shipyard	GS1-2; GS14-15	Green Space	326
	SW1-3; SW6-8	Swale	2581
	PPT1-4	Porous Paving	347
	G1	Gravel	1362
	H1; CHS4	Hard Standing	2978

Zone 2 (Peripheral areas):

The catchments for Zone 2 are summarised in the following table:

Table 8: Zone 2 catchments

Site	Catchment Name	Details	Total Area (m²)
North Circular Road	GS3-GS7	Green Space	76
	PP1	Porous Paving	784
	RG5-14	Raingarden	162
	RHT1; RHT3	Hard Standing	2294
O'Callaghan Strand Road	GS84-89	Green Space	903
	TP7-9	Tree Pit	83
	CHS14-16	Concrete Hard Standing	1941
Stonetown Terrace Road	RHT2.2; CHS5; CHS4.2	Concrete Hard Standing	677
	PP3	Porous Paving	164
	GS28.2; GS29.2; GS30-32	Green Space	118

Refer to Appendix B3 and B4 for the SuDS catchment delineations for Zone 1 and 2 respectively.

7.1.8 QBAR Calculation

Refer to Appendix B5 for the QBAR calculations for the Cleeves development area.

A QBAR calculation was carried out for the site within the redline boundary (5.10 hectares) to determine the allowable run-off rate, as presented in Appendix B.5.

The $QBAR_{rural}$ figure equates to 9.6 l/s so is taken as 10.2 l/s for the overall development.

Sites that drain to the reservoir (Salesians, PBSA and Stonetown Terrace) are effectively in their own catchment as surface water gets attenuated locally in the reservoir for controlled release via the discharge pipe to the Shannon River. We therefore calculated QBAR for the collated area of the sites to determine the allowable outflow from the reservoir.

The $QBAR_{rural}$ figure for the catchments to the reservoir equates to 5.2 l/s. The flow at the outlet can be restricted to be close to this figure via discharge pipe with bespoke size.

7.1.9 Throttles

Outlet structures are proposed to convey and control the flow out of the attenuation features and SuDS components. Their principal function is to throttle the discharge passed downstream in accordance with the GDSDS and thereby enable the attenuation volume to fill. Outlets can either be on the surface, piped systems or slow seepage systems. Outlets are usually built into the downstream side of attenuation features and SuDS components with easy access for maintenance.

The SuDS components at Cleeves Riverside Quarter have been designed to maximise the volume of surface water stored locally (at source). The following throttles will help to achieve this goal:

Table 9: Proposed throttles

SuDS Technique	Throttle
Swale	Outlet Flow Restrictor (orifice)
Porous Paving	Orifice Plate
Raingardens/bioretention areas/tree pits	Filter Media
Reservoir	Outlet Pipe

Each type of throttle is described in more detail below:

Orifice Plate

An orifice is a circular or rectangular opening of a prescribed shape and size that allows a controlled rate of outflow when the orifice is submerged. The flow rate depends on the height of water above the opening (hydraulic head) and the size and edge treatment of the orifice. When using a simple orifice plate, the flow rate passing through the control is directly proportional to the square root of the upstream head. We propose that orifice plates be installed in the wall of an outlet flow control chamber.

$$Q = C_d \, A_o \sqrt{2gh}$$

Where:

Q = orifice discharge rate (m^3/s)

C_d = coefficient of discharge (m) (0.6 if material is thinner than orifice diameter; 0.8 if material is thicker than orifice diameter, 0.92 if edges of orifice are rounded)

A_o = area of orifice (m^2)

h = hydraulic head (m)

g = 9.81 m/s^2

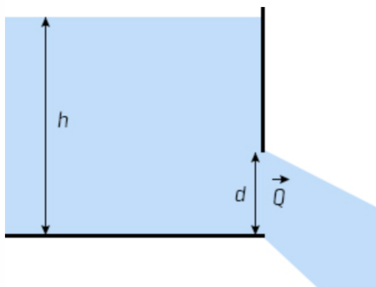

Figure 4: Orifice formula

We have considered 10mm, 20mm, 25mm and 50mm orifice plates. The following table indicates the discharge rate and velocity through the orifice for a range of heads up to 1m:

Table 10: Discharge through orifice

Head (m)	Hydraulics through Orifice							
	50mm		25mm		20mm		10mm	
	Q (l/s)	v (m/s)	Q (l/s)	v (m/s)	Q (l/s)	v (m/s)	Q (l/s)	v (m/s)
0.1	1.71	0.86	0.43	0.87	0.27	0.87	0.07	0.87
0.2	2.41	1.23	0.60	1.23	0.39	1.23	0.10	1.23
0.3	2.95	1.50	0.74	1.50	0.47	1.50	0.12	1.50
0.4	3.41	1.74	0.85	1.74	0.54	1.74	0.14	1.74

Head (m)	Hydraulics through Orifice							
	50mm		25mm		20mm		10mm	
	Q (l/s)	v (m/s)	Q (l/s)	v (m/s)	Q (l/s)	v (m/s)	Q (l/s)	v (m/s)
0.5	3.81	1.94	0.95	1.94	0.61	1.94	0.15	1.94
0.6	4.18	2.13	1.04	2.13	0.67	2.13	0.17	2.13
0.7	4.51	2.30	1.13	2.30	0.72	2.30	0.18	2.30
0.8	4.82	2.46	1.21	2.46	0.77	2.46	0.19	2.46
0.9	5.12	2.61	1.28	2.61	0.81	2.61	0.20	2.61
1.0	5.39	2.75	1.35	2.75	0.86	2.75	0.22	2.75

The maximum head of water on the orifice plate in the swale is circa 1m, resulting in a restricted flow rate through a 10mm orifice of 0.22 l/s at a velocity of 2.75 l/s. Although a 10mm orifice seems small, the SuDS proposals outlined in this report already incorporate a high level of mitigation against blockages in the form of the stone filtration and geotextile wrapping on the perforated pipes. This will prevent large particles getting through to the pipe and the catchpit manhole just upstream of the orifice plate will offer a third line of defence against blockages. The velocity through the 10mm orifice plates for nominal heads is greater than 1m/s so they should be largely self-cleansing.

Filter Media

This material is normally sand based with some source of organic matter and slow-release plant nutrients to maintain healthy plant growth. It filters out pollutants and controls the rate at which water filters through the system. Careful selection of the filter media in the planted areas will restrict the rate of discharge out of the base of the planted areas in extreme rainfall events, effectively serving as a throttle. The permeability of generic soil filter media is assumedto be 300mm/hr.

However, to allow for initial clogging the design is based on 50% of the measured hydraulic conductivity of the compacted medium. In assessing the performance of the bioretention areas we have assumed an infiltration rate of 100mm/hr, equivalent to a flow rate of 0.03 l/s per meter squared of planted area.

Discharge pipe from the reservoir to Shannon River

A 225 mm diameter discharge pipe is proposed to be laid horizontally from the attenuation reservoir to the newly constructed final manhole, with an invert level of +1.00 m ODM. The pipe has been sized to significantly restrict outflow from the reservoir, ensuring controlled discharge to the River Shannon during 1:100 year storm event.

Hydraulic modelling indicates that the maximum head of water at the outlet pipe will be 0.93 m, resulting in a restricted flow rate of 42.97 l/s at a velocity of 1.08 m/s. Whilst this is higher than the QBAR rate, it is somewhat below the existing brownfield runoff rate. For context as to why this diameter pipe and flow is considered to be appropriate and practical, see flows in overall summary Table 13 , in Section 7.1.1.

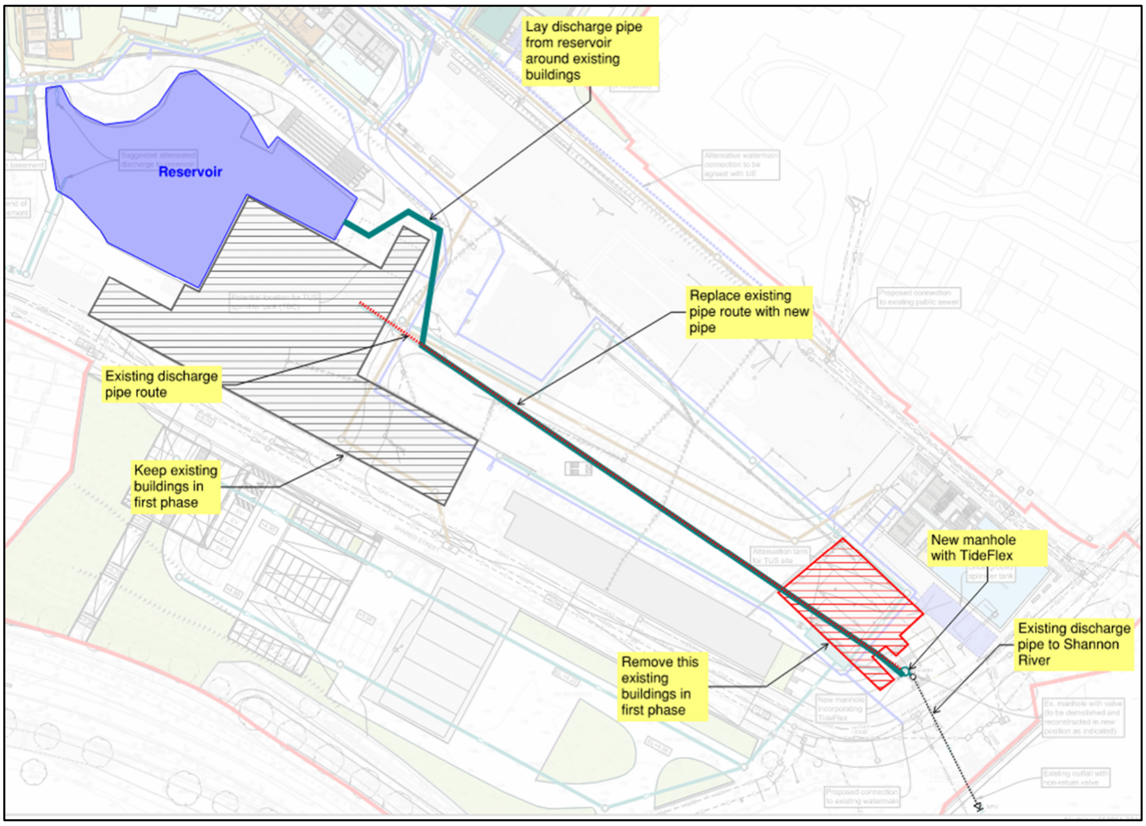

Figure 5: Discharge pipe to Shannon River

Water feature

The quarry face separating the Salesians and Stonetown Terrace sites at the upper level from the PBSA site at the lower level offers an opportunity to convey the water from the upper to lower levels in a visible, audible and engaging way rather than in a conventional piped system. This will aid in mirroring the natural hydrological cycle to visually connect the spaces, with added benefits of aerating the water and bringing aesthetic and sensory appeal to the management of the surface water.

A challenge in designing for this concept is managing the range of flows associated with the full range of return period storms between the 1:1 to 1:100 year return period storm events. This can be achieved via a flow control structure located at the upper level to collect the range of flows and convey them in a controlled fashion to the lower level.

Arup and Landscape Architect developed the following water feature concept for the Salesians site

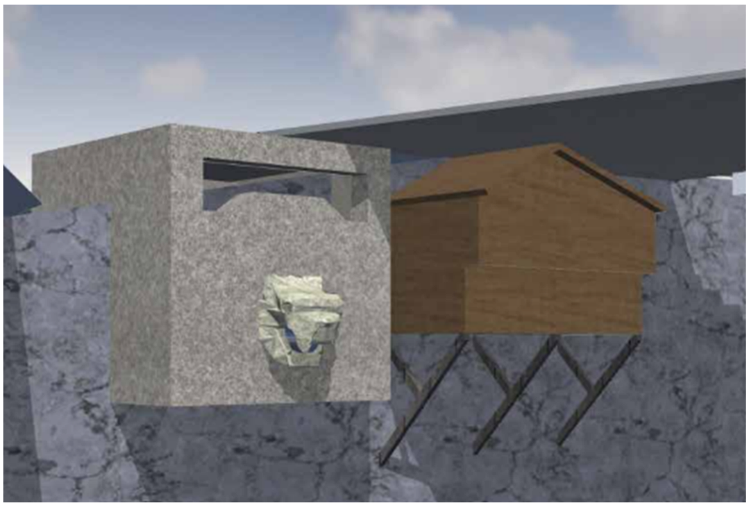

Figure 6: Proposed upper & middle water features at Salesians

This structure is designed to collect water in the single compartment, which has a small outlet pipe or spout that will discharge water at a low rate to the lower level during frequent, smaller rainfall events. The spout will be fixed with a down-turned nozzle to intercept the water so that it falls directly downward without a trajectory. This will prevent any disruptions caused to pedestrians who might be using the walking deck.

When larger storms occur, compartment would fill due to the limited capacity of the small outlet and spill over the broad crested weir sized to accommodate up the 1:100-year event.

Salesians – Upper outlet
The invert level of the inlet pipe is 8.35 mOD, versus a reservoir maximum water level of 2.00 mOD i.e. a vertical drop of 6.35m.

In the worst-case scenario for the largest storm (1m head of water in the structure) the water will exit the structure at a velocity of 2.7 m/s.

The 1:100-year discharge from the Salesians site feeding the upper outlet is 32.8 l/s. The 100mm outlet pipe, with an upstream head of 1m, can accommodate a flow of 35 l/s implying the upper slot/spillway will rarely if ever be activated. Reducing the outlet pipe diameter will activate the slot/spillway in a more meaningful way.

Salesians – Middle outlet
The structure for the middle outlet is proposed to be the same as that for the upper level.

The invert level of the inlet pipe is 6.34 mOD, versus a reservoir maximum water level of 2.00 mOD i.e. a vertical drop of 4.34m.

The 1:100-year discharge from the Salesians site feeding the outlet is 67.7 l/s. A 150mm outlet pipe, with an upstream head of 1m, can accommodate a flow of 48 l/s implying the upper slot/spillway will be activated in some events.

Salesians – Lower outlet
Due to the limited height between the pipe invert and the reservoir surface we are not proposing any flow control structure, but rather a free outlet protected with a headwall to allow for the 28.9 l/s.

The invert level of the inlet pipe is 4.41 mOD, versus a reservoir maximum water level of 2.00 mOD i.e. a vertical drop of 2.41m.

Stonetown Terrace – Cascade feature
The Stonetown Terrace site has a further complication in that the quarry face is remote from the reservoir (with development between the two zones) so the conveyance from the upper to lower level (maintaining the philosophy of visual engagement with the water) will need to take a different form i.e. cascade feature fixed to the quarry wall.

Arup has engaged extensively with the landscape architect about how best to combine aesthetic (form) with engineering (function) for each of the outlet structures.

The emerging aesthetic for the discharge from upper level of Stonetown Terrace to the lower level is depicted in the image below i.e. a vertical pipe connected to the outlet, discharging to a series of channels fixed retaining wall creating a cascading water feature underlain by a rain garden at ground level below. From the water feature, the discharge will fall onto a hydraulically compact bioretention zone at lower ground and be captured in an underground piped network before descending to reservoir.

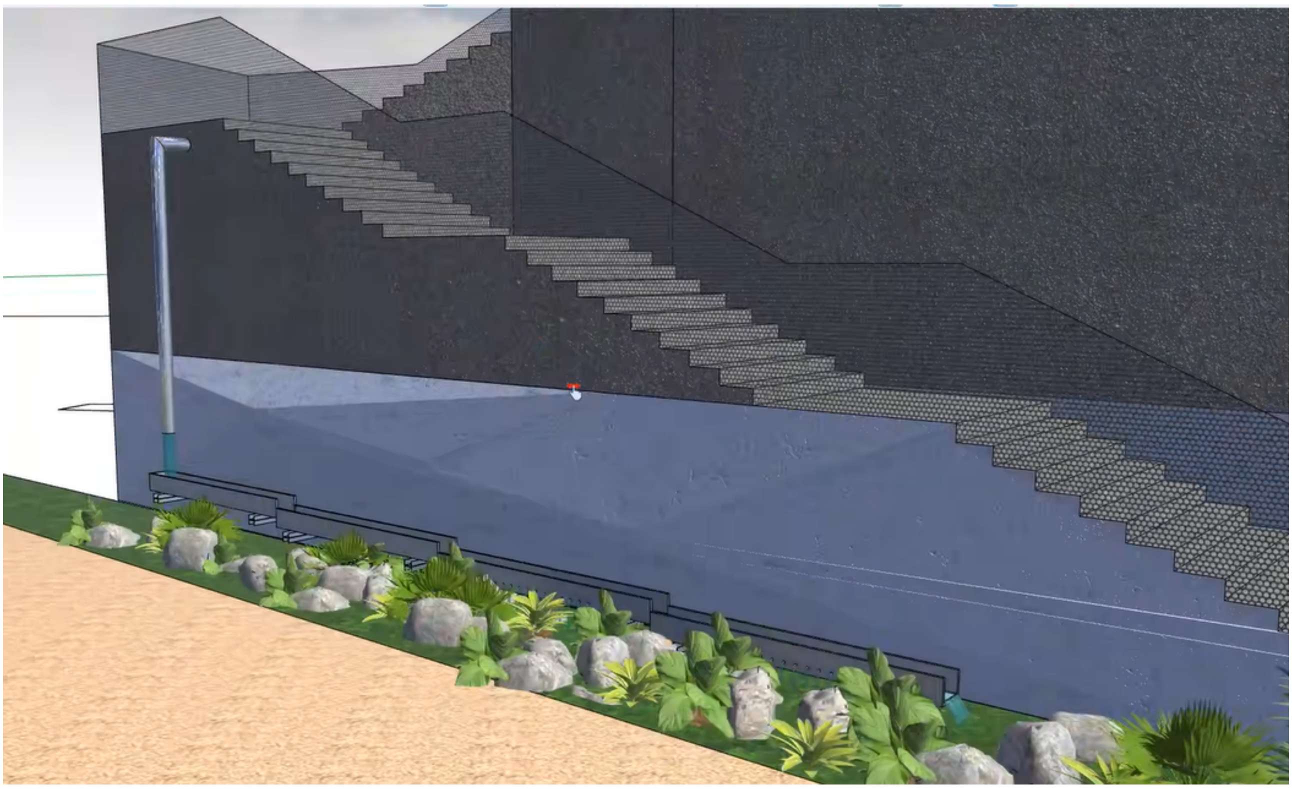

Figure 7: Water feature at Stonetown terrace site

The peak discharge from the Stonetown terrace site for the 1:100-year rainfall event is 43.5 l/s through a 225mm pipe.

A vertical pipe with vent would be required at the outlet pipe at high level to direct the flow through 90 degrees down to the alignment of the cascading water feature at a lower level. The elevation drop between Stonetown Terrace to PBSA site is 2.74m.

The cascading channels would need to be a minimum dimension of 250mm wide by 250mm deep. The hydraulics of the channels for a range of flows are shown in the following table:

Table 11: Hydraulics of channel for Stonetown Terrace water feature

Flow Rate (L/s)	Flow Depth (m)	Velocity (m/s)
10	0.049	0.816
20	0.079	1.013
30	0.105	1.143
40	0.13	1.231
50	0.155	1.29
60	0.178	1.348
70	0.201	1.393
80	0.224	1.429

7.1.10 Piped Networks per Zone

All existing utility services within the Cleeves development site are to be decommissioned and removed with the exception of the combined sewer located at the north-western corner of the Salesians site. This sewer currently transverses the site boundary and connects to the neighbouring Salesian Primary School property. It is proposed to divert this combined sewer via a 160 mm diameter pipe, rerouting it off-site in accordance with the drainage strategy.

The surface water drainage network for the Cleeves development is proposed to be constructed as a gravity fed piped system as follows:

- Zone 1 – Gravity drainage from the green roof, discharging directly into rain gardens and subsequently into the final discharge pipework
- Zone 1 – Gravity drainage from hard landscaped areas, planter box overflows, and raised planted area overflows, discharging into the final pipe network
- Zone 2 – Gravity drainage from bioretention areas (rain gardens), with flow throttled prior to discharge into the public drainage system.

An independent surface water drainage system is proposed for each site within the development. These systems will operate separately until they converge at the newly constructed final manhole, from which the combined flow will discharge to the existing outfall leading to the Shannon River.

See Appendix A for detailed wet service drawings for Zone 1 and 2 of the Cleeves development.

7.1.11 Hydraulic Calculations per Zone

Zone 1 volumetric calculations (m3)

The volumetric runoff for each site (see Appendix B.6) was calculated using a rainfall depth of 77.53 mm and runoff factors as detailed in Section 7.1.3.

The runoff volumes per site, including runoff destination, are presented in the Appendix B.6 below.

The various proposed SuDS techniques (see Section 7.1.6) were then sized to store the calculated volume locally for rainfall events up to and including the 1:100-year event plus 30% for climate change and 10% for urban creek, for slow release once the storm abates.

Storage is proposed in the following locations:

- Green roof
- Tree pits/rain gardens
- Raised planted areas
- Porous Paving
- Swales
- Reservoir

The volume of rain falling on the footprint of Zone 1 has been calculated as 3377 m^3. Of this, 436 m^3 is removed through infiltration, interception and evapotranspiration, with the remaining 2941 m^3 distributing between the swales, raingardens, tree pits, porous paving and raised planters, and the remainder discharging directly, without SuDS intervention into the existing drainage network or reservoir.

These figures are summarised in the following table:

Table 12: Volume stored in SuDS techniques and Reservoir – Zone 1

SuDS Technique	Volume stored (m^3)	Comments
Swales	520.5	Each swale discharges through a 10mm orifice at 0.22l/s to the piped network
Raingardens	540.7	Discharges through filter media at 0.03l/s/m^2 of planted area to the piped network
Tree Pits	207.5	Discharges through filter media at 0.03l/s/m^2 of planted area to the piped network
Porous Paving	53.5	Each porous paving discharges through a 10mm orifice at 0.22l/s to the piped network
Raised Planters	1.5	Discharges through filter media at 0.03l/s/m^2 of planted area to the piped network
Total	1323.7	
Other	**Volume stored (m3)**	**Comments**
Reservoir	1288.5	Discharges at 42.97l/s through a 225mm gravity pipe, flow is naturally regulated by pipe diameter and available hydraulic head. Maximum hydraulic head is 0.9m for 1:100 year storm.

The controlled flow from SuDS features within Zone 1, along with the locations of the proposed controls, can be seen below in Appendix B.8.

The philosophy for each SuDS technique/drainage zone and hydraulic sizing is described below:

Green Roofs

Green roofs are proposed for the Salesians, PBSA and Stonetown Terrace sites, with a coverage of 25% of the total roof area for PBSA and Stonetown Terrace, and 15% coverage of the total roof area for the Salesians site. The first 10mm of rainfall on the existing buildings is intercepted by the green roof. All subsequent rainfall is brought to the rain gardens and hard surface on ground level.

The green roofs have been sized to store the entirety of the excess 1 in 100-year rainfall event.

Planter boxes

See catchment delineation Drawings in Appendix B.3 showing locations of planter boxes in Zone 1, with corresponding hydraulic calculation tables in Appendix B.6.

Surface water from the roof downpipes will be routed to the adjacent rain gardens. The planter boxes have been sized to store the entirety of the 1 in 100-year rainfall event.

The filter media within the planter boxes serves as the throttle, restricting the rate of flow to the piped network.

Bioretention areas (raised planted areas)

See catchment delineation Drawings in Appendix B.3 and B.4 showing locations of the proposed bioretention areas in Zone 1 & Zone 2 respectively, with corresponding hydraulic calculation tables in Appendix B.6 & B.7.

We propose bioretention planting on level 1 of the PBSA development to manage surface water run-off.

These areas will offer interception storage of circa 30%, with the surplus runoff draining to the piped network.

Porous Paving

The porous paving collects runoff from the adjacent parking spaces and some soft landscaped areas. They are underlain by a filter drain that has piped connections from the throttled to the piped network. The filter drain network and stone base (30% void ratio) have a capacity to store 53.3 m3.

See catchment delineation Drawings in Appendix B.3 & B.4 showing locations of porous paving in Zone 1 & 2 respectively, with corresponding hydraulic calculation tables in Appendix B.6 & B.7.

Swales

Appendix B3 shows the catchment delineation, with corresponding hydraulic calculation tables in Appendix B6.

The ground level gravel and paving areas are linked to the swale/detention basin with a flow restrictor installed at the outlet of the swales.

SW1, SW2, SW3, SW6, SW7, SW8 connect to the piped network, with the flow restricted via an orifice plate in the outlet pipe.

The total rate of water leaving the swales/dry detention basins is circa 0.9 l/s.

Reservoir

See Appendix B.3 showing the location of the proposed attenuation reservoir.

This reservoir collects runoff from the adjacent sites (Salesians, PBSA and Stonetown Terrace) for restricted discharge to the Shannon River.

It has capacity to store 1289m^3 of runoff volume from the surrounding sites, which accounts for circa 40% of the total volumetric runoff from Zone 1.

Zone 1 discharge calculations (l/s)

The estimated existing/pre-development runoff from Zone 1 is 819.8 l/s based on a rainfall intensity of 77.53mm/hr for the 1:100-year rainfall event.

The post development runoff from Zone 1 following implementation of all the SuDS measures is 164.7 l/s discharging to the Shannon River, apportioned as follows:

- 42.97 l/s along the outfall from the reservoir (attenuated flows from Salesians, PBSA, Stonetown Terrace)
- 121.7 l/s from the remainder of Zone 1 (Flaxmill Plaza, Shipyard, O'Callaghan Strand)

This represents an 80% reduction in peak discharge from Zone 1 post implementation of the SuDS measures. The breakdown of the pre vs post development comparison runoff and discharge is detailed in the table below.

Table 13: Detailed comparison of Zone 1 pre and post development volumetric runoff and peak discharge

Site/Zone					Pre Development		Post Development	
	Area (m^2)	Rainfall Depth (mm)	Greenfield (C=0.2) Runoff Rate (L/s)	Qbar (L/s)	Runoff Volume (m^3)	Discharge Rate (l/s)	Runoff Volume (m^3)	Discharge Rate (l/s)
Salesians	10013	77.5	43.2		665.7	185.1	637.4	129.4
PBSA	6896	77.5	29.7		470.7	128.1	441.0	101.6
Stonetown Terrace	3677	77.5	15.9		121.3	33.7	204.6	43.5
Reservoir	5354	77.5	23.1		297.8	82.8	314.6	92.0
Subtotal Zone 1 (Reservoir Inflow)	**25940**		**111.8**		**1546**	**429.6**	**1597.6**	**366.6**
Subtotal Zone 1 (Reservoir Outflow)				**5.2**				**43.0**
The Flaxmill Plaza	7593	77.5	32.7		696.1	193.5	670.4	84.9
O'Callaghan Strand	1869	77.5	8.1		144.9	40.3	136.3	35.1
Shipyard	8978	77.5	38.7		562.4	156.4	536.6	1.7
Subtotal Zone 1 (remaining sites)	**18440**		**79.5**	**3.69**	**1403.4**	**390.1**	**1343.3**	**121.7**
Total Zone 1	44380		191.2	8.88	2948.9	819.8	2941	164.7

7.1.12 Hydraulic Calculations – Zone 2

Zone 2 volumetric calculations (m3)

The volumetric runoff for each catchment (see Appendix B.4) was calculated using a rainfall depth of 77.53 mm and runoff factors as detailed in Section 7.1.3.

The runoff volumes per catchment, including runoff destination, are presented in the Appendix B.7 below.

The various proposed SuDS techniques (see section 8.1.6) were then sized to store the calculated volume locally for rainfall events up to and including the 1:100-year event plus 20% for climate change, for slow release once the storm abates.

Storage is proposed in the following locations:

- Porous paving
- Bioretention areas (rain gardens; tree pits)

The volume of rain falling on the footprint of Zone 2 has been calculated as 558 m^3. Of this, 103 m^3 is removed through infiltration, interception and evapotranspiration, with the remaining 455 m^3 distributing between the swales, raingardens, tree pits, porous paving and raised planters, with a portion discharging directly, without SuDS intervention into the existing drainage network.

These figures are summarised in the following table:

Table 14: Volume stored in SuDS techniques – Zone 2

SuDS Technique	Volume stored (m3)	Comments
Porous Paving	44.1	Discharges through a 10mm orifice at 0.22l/s to the piped network.
Rain garden	103.9	Discharges through filter media at 0.03l/s/m^2 of planted area to the piped network.
Tree pits	4.4	Discharges through filter media at 0.03l/s/m^2 of planted area the piped network.
Total	152.4	

The controlled flow from SuDS features within Zone 2, along with the locations of the proposed controls, can be seen below in Appendix B.8.

The philosophy for each SuDS technique/drainage zone and hydraulic sizing is described below:

Porous Paving

See Appendix B.4 showing the proposed porous paving to the service area along the western end of the development.

The strategy is to store surface water runoff in the stone layer and filter drain beneath the surface i.e., effectively an in-situ attenuation tank.

The discharge will be throttled at the downstream end of each compartment via installation of a catchpit and orifice plate.

Bioretention areas (rain gardens; tree pits)

See drawing Appendix B.4 showing the location of the proposed bioretention areas.

These areas will offer interception storage of circa 30%, with the rain gardens being further sized to accommodate the 1:100-year rainfall volume.

The excess runoff from the bioretention areas will be drained to the piped network.

Zone 2 discharge calculations (l/s)

The estimated existing/pre-development runoff from Zone 2 is 147.7 l/s based on a rainfall intensity of 77.53mm/hr for the 1:100-year rainfall event.

The post development runoff from Zone 2 (roads) following implementation of all the SuDS measures is 91.9 l/s. Zone 2 runoff will be collected by a combination of existing gulleys/network as well as proposed retrofit SuDS.

This represents a 38% reduction in peak discharge from Zone 2 post implementation of the SuDS measures. The breakdown of the pre vs post development comparison runoff and discharge is detailed in the table below.

Table 15: Detailed comparison of Zone 2 pre and post development volumetric runoff and peak discharge

Site/Zone					Pre Development		Post Development	
	Area (m^2)	Rainfall Depth (mm)	Greenfield (C=0.2) Runoff Rate (L/s)	Qbar (L/s)	Runoff Volume (m^3)	Discharge Rate (l/s)	Runoff Volume (m^3)	Discharge Rate (l/s)
North Circular Road	3316	77.5	14.3		257.1	71.5	224.3	28.4
O'Callaghan Strand Road	2928	77.5	12.6		197.3	54.8	169.0	48.2
Stonetown Terrace Road	1077	77.5	4.6		76.8	21.4	61.9	15.3
Total Zone 2	7320	77.5	31.6	1.46	531.2	147.7	455.2	91.9

7.2 Proposed Foul Water Drainage System

7.2.1 Design Criteria

It is envisaged that the design approach for foul water services from each site will have individual connections to the adjacent Uisce Éireann foul sewers on NCR, O'Callaghan Strand and on Stonetown Terrace.

A Confirmation of Feasibility has been received from Uisce Éireann which has confirmed that the proposed watermain connections are feasible without upgrades to the network. Refer to Appendix C.4 for the received Confirmation of Feasibility from Uisce Éireann.

The buildings will be catered for by individual foul drainage networks within each site discharging to the final connection points. This approach will need to be discussed and agreed with Uisce Éireann when the site layouts and the accommodation / units have been finalised. The key strategies for the wastewater system are the use of gravity networks to avoid the need for pumping where possible, the use of the existing combined sewer to the southwest, and the implementation of demand reduction strategies such as the use of low flow fixtures and fittings.

The key objectives to achieve the strategy are:

- Gravity Networks - The uniform sloping nature of the terrain generally supports the use of gravity sewer collection systems. These will be used where possible to avoid the need for pump stations and associated operating and maintenance costs.
- Using Existing Outfall Sewer - The strategy is to connect the wastewater discharges to the existing public sewers along the north circular road.
- Demand Reduction - Sewer discharge volumes are anticipated to reduce in proportion to the reduction in water demand. Some of the water conservation measures regarding this are:
  - Reducing water demand through water saving technologies i.e. flow restrictors
  - Low flow fixtures and fittings/Dual Flush Toilets - Low flow fixtures conserve water by using a high-pressure technique to produce a strong or equal flow of water with less water than more water-wasting fixtures. Dual flush toilets prevent the full contents of the cistern being discharged with every flush
  - Education and Smart Metering - live recording of water consumption patterns to indicate in real time potential problems with the network; can include a user interface to encourage changes in water usage patterns; can support remote meter reading and billing

The use of techniques such as low flow fixtures and fittings and dual flush toilets combined with smart metering and education of the end users, could realistically achieve up to a 30% reduction in potable water consumption and wastewater discharge.

7.2.2 Demand Estimation

Irish Water Code of Practice for Wastewater Infrastructure Water demands

Table 16: Foul demands (Uisce Éireann)

Property Type	Occupants/Population	Flow	Flow	Flow	Peak factor	Total
		l/h/d	l/d	l/s		l/s
Apartments/ Townhouses	788 No. Residents	150	118,200	1.37	6	8.21
Student Accommodation	271 No. Residents	150	40,650	0.47	6	2.82
Commercial/Educational	1161 No. Visitors	90	104,490	1.21	4.5	5.44
Total			263,340	3.05		16.47

The proposed development will have apartments/townhouses across three development sites (Salesians, Stonetown Terrace and O'Callaghan Strand) with an assumed full capacity of 788 No. residents, student accommodation with an assumed full capacity of 271 No. residents and commercial/educational building units with an assumed full capacity of 1161 No. visitors (Flaxmill).

Irish Water Hydraulic Design Guidance of 150 l/h/d for a residential unit, and 100 l/h/d for a commercial/educational building serving visitors.

The estimated daily wastewater hydraulic loading would be 263.3 m^3/d, for the proposed development.

This figure equates to an average (DWF) of approximately 3.05 l/s based on a 24-hour day.

Assuming a peaking factor from Irish Water Wastewater Code of Practice of 6 times DWF for residential unit peak discharge, and 4.5 times DWF for commercial/building visitor unit peak discharge. The peak discharge would be 16.47 l/s.

7.3 Proposed Watermain

7.3.1 Design Criteria

There will be specific potable water storage and design requirements for high-rise and large-scale developments on the various sites as well as for firefighting purposes. It is envisaged that the design approach for the provision of potable water to each site will be stand alone, i.e., individual ring mains for each site, with separate metered connections to the existing Uisce Éireann (UE) mains adjacent to each site.

A Confirmation of Feasibility has been received from Uisce Éireann which has confirmed that the proposed wastewater connections are feasible without upgrades to the network. Refer to Appendix C.4 for the received Confirmation of Feasibility from Uisce Éireann.

The intention is for all new developments to be supplied via a ring main system connected to the existing campus network with new sluice valves and hydrants located to meet the requirements of the current Part B Building Regulations and the Local Fire Officer. Any storage or pressure boosting required for use within the new buildings will be designed as part of the MEP scope for each building. No specific capacity issues with the campus distribution system have been identified during the desk study.The key objectives for the water supply are:

- Resilience - Consider options to supply the development on a ring main system fed from more than one source. Sizing assets to ensure current and future demands can be met
- Demand Reduction strategies to reduce the reliance on potable water, e.g. the use of well water or rainwater harvesting

7.3.2 Demand Estimation

The anticipated average water demand is 3.447 litres / second with a peak demand of 18.506 l/s.

8. Summary

8.1 Surface Water

This report outlines the civil engineering design proposals for the proposed Cleeves Riverside Quarter development. The proposals have been workshopped and aligned with the latest Architect and Landscape Architect drawings.

The overall objective is to drain each site as an independent network to enable phasing of the works. It is proposed to discharge the surface water from the development to the Shannon River via the existing 400 mm diameter discharge pipe. The existing final manhole will be replaced with a new structure, while the existing discharge pipe will be extended to connect to the new manhole.

A key area of focus is green infrastructure (GI). GI is a strategically planned and delivered network of natural and man-made green (land) and blue (water) spaces that sustain natural processes. GI delivers a wide variety of benefits for biodiversity, amenity, health and wellbeing and climate change adaptation. GI in the context of drainage translates into Sustainable Drainage Systems (SuDS). SuDS are designed to maximise the opportunities and benefits that can be secured from surface water management.

The site comprises the following zones:

- Zone 1: Site catchments (Salesians, PBSA, Stonetown Terrace, Reservoir, Flaxmill Plaza, Shipyard, O'Callaghan Strand)
- Zone 2: Peripheral areas (North Circular Road, O'Callaghan Strand Road, Stonetown Terrace Road)

We propose implementing a range of SuDS techniques covering most of the site footprint. i.e., green roof, bioretention areas (planter boxes; raised planted areas; rain gardens; tree pits), porous paving, swales and attenuation reservoir.

The intention is to manage surface water runoff as close to source as possible. Where possible we have linked these SuDS features in a Management Train to facilitate the capture, conveyance and storage of surface water runoff as close to source as possible whilst delivering interception and pollutant risk management.

Most of these SuDS features can be designed to accommodate runoff up to and including the 1:100-year rainfall event. Where constraints such as sloping topography exist, interventions such as the installation of check dams and throttles can be made to maximise the storage of water at source e.g. on the porous paving system.

The volumetric runoff (pre and post development) and peak discharge (pre and post development) has been calculated for Zones 1 and 2, summarised as follows:

Table 17: Comparison of pre and post development volumetric runoff and peak discharge

Area	Greenfield runoff rate (l/s)	Qbar (l/s)	Volumetric Runoff (m^3)			Peak Discharge (l/s)		
			Pre-development	Post- development	% reduction	Pre-development	Post-development	% reduction
Zone 1	191.2	8.9	2,949	2,941	0	819	165	80
Zone 2	31.6	1.5	531	455	14	148	92	38
Overall Site	222.8	10.4	3,480	3,396	2	967	257	73

If the full extent of the SuDS measures discussed in this report is implemented:

- The **volumetric** surface water runoff will be reduced by 84 m³, representing a 2% reduction versus pre-development. This is nominal as expected, given attenuation features predominantly store water temporarily rather than removing it completely. The nominal reduction can be attributed to evapotranspiration and infiltration occurring in the various SuDS techniques, which reduce the impermeable area of 78% (pre-development) to 65% (post-development)
- The **peak discharge** from the site will be reduced by 710 l/s, representing a 73% reduction versus pre-development, through installation of various throttles in strategic locations i.e. orifice plates and infiltration techniques (e.g. rain gardens; porous paving, swales) and the restricted discharge pipe from the attenuation reservoir

The QBAR rate for the 5.1 ha Cleeves site has been calculated to be 10.2 l/s in accordance with the Greater Dublin Strategic Drainage Study (GDSDS) guidelines.

However, the Cleeves development is a large brownfield site, and it is not considered feasible to restrict the post-development discharge to the QBAR rate.

A more realistic benchmark is the pre-development discharge rate. Notwithstanding the significant improvements that have been demonstrated against that benchmark, we have tabled a SuDS scheme that achieves a 14% decrease in the hypothetical greenfield runoff rate for Zone 1 and a slight increase relative to the greenfield runoff rate for Zone 2. This results in the post development runoff rate being reduced to almost greenfield rates, with significant benefits to the receiving environment.

We do not consider it feasible or practical to reduce this rate any further. It would necessitate the installation of large-scale attenuation tanks on the Flaxmill Plaza and O'Callaghan Strand sites, where the available space is already significantly constrained. This would attract disproportionately high capital and ongoing maintenance costs relative to the modest additional reduction that would be achieved. Additionally, the increased material and construction requirements would negatively impact the project's overall carbon footprint.

We therefore respectfully request that An Coimisiún Pleanála consider a relaxation of the usual maximum allowable runoff rate (QBAR) given the significant reduction in previous post development runoff that will be achieved via implementation of the tabled SuDS scheme i.e. a reduction to almost greenfield runoff rates. The proposed drainage strategy ensures minimal impact on the River Shannon as the receiving water body.

8.2 Foul

The proposed foul drainage strategy involves individual connections from each site to the adjacent Uisce Éireann sewers on NCR, O'Callaghan Strand and on Stonetown Terrace roads. Each building will have its own foul drainage network discharging to designated connection points.

The anticipated average foul discharge for the Cleeves development (i.e. combined occupancy of Salesians, Stonetown Terrace, PBSA, O'Callaghan Strand, Flaxmill Plaza sites) is 3.05 l/s with a peak discharge of 16.47 l/s.

8.3 Water

The proposed water supply strategy includes specific potable water storage and design requirements for high-rise and large-scale developments on the various sites, as well as to meet firefighting requirements. It is envisaged that each site will have a stand-alone design approach for the provision of potable water, using individual ring mains, with separate metered connections to the existing Uisce Éireann mains adjacent to each site.

The water supply strategy focuses on reduction by minimising reliance on potable water through well water and rainwater harvesting. Resilience is addressed through a ring main system fed from multiple sources, sized to meet both current and future demand.

The anticipated average water demand for the Cleeves development (i.e. combined occupancy of Salesians, Stonetown Terrace, PBSA, O’Callaghan Strand, Flaxmill Plaza sites) is 3.447 l/s with a peak demand of 18.506 l/s.